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Extract From

"THE WESTERN HEMLOCK SAWFLY AND ITS PARASITES IN OREGON"

by
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Portland Station
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"THE WESTERN HEMLOCK SAWFLY AND ITS PARASITES IN OREGON"

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An extensive outbreak of the western hemlock sawfly, Neodiprion tsugae (Rof.) Sargent, occurred near Sweet Home, Oregon, in the years 1933 to 1936 inclusive. The following observations were made on the life hostory and habits in Oregon as well as the life histories and habits of the many parasites that were reared from N. tsugae cocoons. N. tsugae is comparatively new in entomological literature. The adults were described by Middleton (1933) from material taken at Carroll Inlet, Alaska and from the Queen Charlotte Islands, B. C.

Hopping and Leach (1936) worked out the life history and habits at Vancouver, B. C. and described the egg, 5 larval instars and the cocoon.

Distribution and hosts: August 23, 1930 one female was reared in association with Peronea variana Fern, on western hemlock at Sappho, Washington. Another female was reared October 15, 1932 in association with Ellopia fiscellaria var. lugubrosa Hulst. on western hemlock at Montesano, Washington. On June 27, 1937, several larvae were beaten from western hemlock foliage near Fairfax, Washington. From these larvae 3 female adults were reared during September of the same year. In 1936 no appreciable defoliation occurred, although in the fall newly formed cocoons were abundant enough for a man working 8 hours to collect between 1,000 and 1,500 cocoons. No trees are known to have died solely as a result of the sawfly defoliation. Those that do die

have been found to be infested with a root rot, Polyporus dryadeus Fr., which greatly weakened the trees.

Life history and habits: The life cycle was worked out by rearing larvae under laboratory conditions and by supplementing these observations with field observations.

At Sweet Home the egg laying period began near the middle of August and continued until about the end of September. The eggs were deposited in slits in the edges of the hemlock needles of the current year's growth only. In practically all cases there was one egg to a needle and usually this was placed between the middle and the tip of the needle. A few needles contained two eggs, but none was seen with more than two. The egg is light yellowish-white in color, considerably flattened, and ovoid in general outline. For the most part the winter is passed in the egg stage. A small percentage of the population overwinters as prepupal larvae in cocoons.

With the advent of warm weather the embryo begins to develop, causing the egg to swell until the slit in the needle opens and one side of the egg is exposed. The larvae escape by breaking through the portion of the chorion that is free of the needle.

Upon hatching, the young larvae migrate from the needles in which the eggs overwinter. In the forest they migrated several inches to nearby sprays of foliage when feeding was begun near the tips of the old needles. At this stage, from 3 to 5 larvae usually feed together on a single needle, with their heads toward the apex of the needle.

When a field collection was made on July 9, 1936 a few eggs had hatched, but practically all were just beginning to swell and show the dark eye spots of the developing embryos. A number of the unhatched eggs and a few first instar larvae were collected and taken to the laboratory at Portland, where hatching was completed by July 15. Observations were made on the development of larvae that were reared on hemlock foliage in glass jars. Some of these larvae were reared individually, while others were reared in groups of 10 or 20. Fresh foliage was supplied daily. Under laboratory conditions the period from the hatching of the egg to the spinning of the cocoon ranged from 17 to 35 days, with 25 days being about average. It is believed that development took a few days longer in the forest. Considerable difficulty was experienced in rearing larvae individually, for solitary small larvae were usually unable to initiate attacks upon the hemlock needles. Consequently, only 5 sawflies were successfully reared from egg to adult in isolation. Of these, 2 were females and 3 were males. In each case there were 5 feeding instars and a prepupal, non-feeding instar. One larva that died in the prepupal stage moulted 6 times. Averages taken from the individually-reared larvae show that the duration of the instars, from 1st to 5th, was 6, 4, 3, 4, and 6 days respectively.

"Females of several species of Neodiprion have one more instar than the males."

The prepupal larvae transform to the pupa inside the cocoon. Although duration of the pupal period is not known, observations were made on the length of time spent in the cocoons by 75 individuals that spun in 1936 and emerged the same fall. The shortest time spent in the cocoon was 23 days, the longest 52 days, and 38 days was average. Under laboratory conditions, larvae that spun first took considerably longer to emerge than those that spun last, so that most of the adults emerged during a comparatively short period. No marked difference was found between the time of emergence of the males and of the females. Relatively little information is available concerning the proportion of the sexes. In the fall of 1934, 385 sawflies were reared, of which 53.8 percent were males; whereas in the fall of 1936 a lot of 90 reared adults included 36.7 percent males.

Natural Control: Neither climatic factors nor disease killed a conspicuous number of N. tsugae during the period these observations were made. A few diseased larvae were observed but the number was negligible. Predatory mammals, on the other hand, killed a large number of N. tsugae in cocoons, particularly those in the loose duff. It was roughly estimated that about 50 percent of the cocoons formed on the ground were destroyed by these agents. As contrasted with this, cocoons that were spun under bark plates and under moss on rocks, on solid logs, and on tree trunks overwintered without appreciable damage by mammals. Insect parasites killed a rather high percentage of the N. tsugae population, as will be seen in the following discussion.

Insect Parasites: Data regarding parasitization of N. tsugae were obtained from 3 large collections of sawfly cocoons made near Sweet Home, Oregon in 1935 and 1936, and sent to New Haven, Connecticut for rearing, and from 10 small collections of cocoons reared at Portland, Oregon. The principal 1935 collection, comprising 7,896 cocoons, was made during the week of September 20, when emergence of both sawflies and parasites was at its height. The majority of the cocoons were obtained from foliage and various exposed places. This collection arrived in New Haven on September 29 and the cocoons were immediately set out for rearing. Emergence is summarized in table 1.

In the fall of 1936 two large collections, totalling 13,097 cocoons, were made. Most of these cocoons were taken from the duff at the base of infested trees. The first collection, consisting of 1,827 cocoons, was made on August 25 and the second, consisting of 11,270 cocoons, was made on September 2, 3, and 4. These two lots, which arrived in New Haven on August 28 and September 8 respectively, were reared separately; but emergence records show no significant differences so they have been combined in table 1.

TABLE I

EMERGENCE FROM N. TSUGAE COCOONS COLLECTED AT SWEET HOME, OREGON AND REARED AT NEW HAVEN, CONNECTICUT

Species emerging	1935 Coll. (7,896 Cocoons)			1936 Coll. (13,097 cocoons)		
	Fall issuance	Spring issuance	Total issuance	Fall issuance	Spring issuance	Total issuance
Primary parasites						
Hymenoptera: Ichneumonidae						
Delomerista sp.		1,223	1,223	1	1,761	1,762
Itoplectis montana Cush.	847	439	1,286	322	45	367
Exenterus sp.		36	36		951	951
Stylocryptus subclavatus (Say)				4	588	592
Pezoporus sp.		51	51	406	29	435
Spilocryptus sp.		21	21	121	127	248
Ischnus sp.		2	2	21	72	93
Mostrus neodiprion Viereck		9	9	27	4	31
Lamachus n. sp.		6	6		22	22
Lamachus sp.		11	11		10	10
Euceros fosciens Davis		5	5	3	15	18
Diptera: Tachinidae						
Zenillia sp.	8	27	35	49	108	157
Phorocera sp.		1	1	30	24	54
Hyperparasites						
Hymenoptera: Ichneumonidae						
Thysiotorus sp.	32	28	60	13	19	32
Panargyreops sp.		6	6	19	20	39
Mesochorus sp.		1	1		3	8

TABLE I (Continued)

	Fall issuance	Spring issuance	Total issuance	Fall issuance	Spring issuance	Total issuance
Primary parasites or Hyperparasites						
Hymenoptera: Pteromalidae						
Tritneptis Klugii (Ratz.)		40	40[a]	6	257	263[c]
Hymenoptera: Ichneumonidae						
Hemiteles tenellus (Say)	47	183	230	52		52
Gelis ferruginosus (Strickl.)	10	21	31	9		9
Status unknown						
Hymenoptera: Pteromalidae						
Amblymerus verditor (Nort.)	3		3[b]	5		5[d]
Hymenoptera: Ichneumonidae						
Undetermined					1	1
Total parasites	970	2,436	3,054	1,088	4,061	5,149
Neodiprion tsugae Midd. (Host)	1,035		1,035	3,570	35	3,605

[a] 40 sawfly cocoons (estimated) produced 366 parasite adults.

[b] 3 " " " " 26 " "

[c] 263 " " produced 2,792 parasite adults.

[d] 5 " " " 53 " "

A comparison of the emergence records from cocoons collected in 1935 and 1936 shows a marked decrease in the relative number of Itoplectes montana and an equally marked increase in the relative number of Exenterus sp., Pezoporus sp., Styiocryptus subclavatus, and Tritneptis klugii obtained in 1936. Possibly an increase in the last 4 species at the expense of I. montana is indicated. It is significant that all four species which showed a marked relative increase in 1936 are ground frequenting species.

Hopping and Leach (1936) reared five hymenopterous parasites (Delomerista sp., Phaeogenes hariolus Cress., Phaeogenes articus Cush., Pezoporus sp., and Oliscampe sp.) from cocoons of the western hemlock sawfly taken on the Queen Charlotte Islands, B. C. Of these, Delomerista sp. and Pezoporus sp. were probably the same species as those reared from the Oregon material. Therefore, in the two recorded outbreaks of this sawfly, 23 different species of parasites have been reared, and 13 of them were previously undescribed. A comparatively large number of cocoons from both collections produced neither adult sawflies nor parasites. Whether this is a normal mortality or whether it was due to methods used in handling was not determined. The cocoons which produced nothing in the 1935 collection were not sampled, but 400 cocoons from the 1936 collection were selected at random and dissected. In 44 there were dead sawfly pupae or unissued adults, in 92 there were dead sawfly larvae which died from an undetermined cause, in 4 there were living parasite larvae that had remained in diapause, and in 260 there were

both dead sawfly larvae and dead external parasite larvae. These figures indicate a high adult sawfly emergence from unparasitized cocoons. They also indicate that there were many cocoons killed by parasites which did not produce parasite adults. Although only 5,149 cocoons (39%) produced adult parasites in 1936, it is estimated on the basis of the 400 dissected cocoons that approximately 8,015 (61%) were actually killed by parasites.

Ten small collections of N. tsugae, totalling 6,447 cocoons, were made during 1934, 1935, and 1936, and reared at Portland, Oregon. They showed the presence of the same species of parasites at two collection points, six miles apart, and provided a comparison of the species of parasites emerging from cocoons collected on the ground and on the foliage. Itoplectis montana, although a common parasite of the cocoons formed on the foliage, is almost nonexistent as a parasite of cocoons formed on the ground. Tritneptis klugii, on the other hand, more commonly parasitizes cocoons formed on the ground.

Biological notes on N. tsugae parasites: Notes regarding the life history of the various parasites on N. tsugae were made whenever possible. Most of the species emerged in such small numbers that only fragmentary notes were obtained, but in a few cases the life histories can be fairly well indicated.

Zenillia sp. is a Tachinid fly which spends the winter as a second instar maggot within the host prepupa. Feeding is completed in the spring and the full-grown maggot cuts its way out of the host

cocoon. The puparium is formed in the soil. Adult flies mate readily under laboratory conditions. Coitus lasting about 45 minutes. Females oviposit on active larvae, laying external, thin shelled eggs which contain fully-developed maggots. The young maggots hatch almost immediately and bore through the host larva's skin within a few minutes. Apparently there is only one generation a year, although a few flies issued the same fall that host cocoons were collected.

Phorocera sp., another Tachinid fly, was not mated in the laboratory, and its life history was not worked out. It lays a white, macrotype egg on the host larva's skin.

Itoplectis montana Cush. is an Ichneumonid parasite belonging to the tribe Ephialtini. Adults mate readily under laboratory conditions. Females eagerly attack exposed sawfly cocoons of several species, boring through the cocoon and laying a large egg within the host prepupa. Under laboratory conditions cocoons buried under about one-fourth inch of peat moss were attacked, but field records indicate that exposed cocoons are more readily parasitized. The winter is spent as an immature larva, and development is completed the following spring. Adults issue from the host cocoons. Apparently more than one brood may develop during a season, for many cocoons collected in the field produced Itoplectis adults the same fall. Delomerista sp. is an Ichneumonid fly belonging to the tribe Ichneumonini. Adults mate readily in the laboratory, and females attack host cocoons, laying a large egg externally on the host

prepupa. The parasite larva feeds externally, completing development and spinning a light cocoon within the host cocoon. The winter is spent in this stage. Pupation takes place in the spring, and the adult parasite emerges after cutting an exit hole in the host cocoon. There is only one generation a year.

Exenterus sp., Euceros faciens Davis, Lamachus sp., and Lamachus n. sp. are all Ichneumonids belonging to the subfamily Tryphoninae. They attack active host larvae, but complete development after the host cocoon is spun. With the exception of Exenterus sp. they were obtained in small numbers. Nothing was learned regarding their life histories, for Exenterus sp. was the only one which oviposited, and none of the eggs developed further. The eggs were laid on the host larva partly imbedded beneath the cuticle.

Spilocryptus sp., Pezoporus sp., Mastrus neodiprioni Vier., Stylocryptus subclavatus (Say), and Ischnus sp. are Ichnumonids of the subfamily Cryptinae. All of them have very similar life histories, which are very nearly identical to that described for Delomerista sp. Apparently they are all multibrooded, for a considerable number issued the same fall that host cocoons were collected.

Gelis ferruginosus (Strickl.) and Hemiteles tenellus (Say) are also Cryptinae, and have life histories similar to the five species in that tribe that have already been mentioned. As a rule, though, they develop as hyperparasites.

Nothing was learned regarding Mesochorus sp., Thysiotorus sp., and Panargyrops sp., but probably they are all internal hyper parasites.

Tritneptis klugii (Ratz.) is a chalcidoid parasite belonging to the family Pteromalidae. Recently Mr. A. B. Gahan (1938) discussed the taxonomic status of this genus and species. T. klugii attacks host cocoons, paralyzing and then laying a number of eggs externally upon the host prepupa. The parasite larvae feed externally, pupating within the host cocoon. If a parasite larva of another species is present in the sawfly cocoon, Tritneptis develops on it in the same manner, and apparently it is more often a hyperparasite than a primary parasite. Fifty cocoons which produced Tritneptis were dissected. In 5 of them it may have developed as a primary parasite, but in 45 the remains of a solitary primary parasite were found. Several broods may develop during the season. An average of 11 adults issued from 263 cocoons parasitized by this species in 1936, but 39 isolated cocoons gave an average of 20 adult Tritneptis with a maximum of 51 and a minimum of 7.

Amblymerus verditor (Norton) is also a gregarious Chalcidoid belonging to the family Peteromalidae. Oviposition by the species was not secured.

Liberations of Neodiprion tsugae parasites: Since Itoplectis montana and Delomerista sp. seemed to be potent factors in controlling N. tsugae in Oregon, several colonies of these parasites were liberated in infestations of Diprion polytomum Htg. in the northeastern part of

the United States, and one colony of Delomerista sp. was liberated in an infestation of Neodiprion sertifer Geoff. in New Jersey. D. Polytomum is presumably an introduced species which has become a serious menace to spruce in eastern Canada and the northeastern part of this country. N. sertifer is a European species which is now known to occur in New Jersey, Ohio, and Michigan. Laboratory experimentation indicated that I. montana does not develop normally as a parasite of D. polytonum, but this parasite is also an important enemy of several lepidopterous defoliators of the Pacific Coast, and might be generally valuable in the northeastern forests. Records obtained from the Division of Insect Identification indicate that Delomerista sp. is already present in the northeastern part of the United States and Canada. The liberations are shown in table 2.

TABLE II

LIBERATIONS OF NEODIPRION TSUGAE PARASITES

Host species	Parasite species	Liberation point	No. liberated
Diprion polytonum	Itoplectis montana	Orange, Conn.	342
		Kent, Conn.	290
		Petersham, Mass.	200
		Tupper Lake, N. Y.	413
	Delomerista sp.	Orange, Conn.	348
		Tupper Lake, N. Y.	330
		Eastford, Conn.	500*
Neodiprion sertifer	Delomerista sp.	Far Hills, N. J.	400*

* Mated females